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Ground Water Test Drilling Sites in the Hartnet, Fremont River, and Hall Creek Areas, Capitol Reef National Park, Utah

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by

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Report to

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GROUND WATER TEST DRILLING SITES IN THE HARTNET, FREMONT RIVER, AND HALL CREEK AREAS, CAPITOL REEF NATIONAL PARK, UTAH

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PURPOSE

The purpose of this report is to identify the best sources for ground water in three parts of Capitol Reef National Park: the Hartnet, Fremont River, and Hall Creek areas. It will be shown that the best target aquifer in each area, considering both water quality and anticipated well yields, is the Navajo Sandstone. It is possible that the overlying Entrada Sandstone could yield good supplies of potable water, but the chances for successfully developing water from this unit are speculative at this time. Water quality in the Navajo Sandstone is unknown within the park but should contain total dissolved solids in the 300-750 milligrams/liter range, with most likely values of about 350-500 milligrams/liter.

LOCATION

Capitol Reef National Park is in south-central Utah and extends about 70 miles from the Hartnet area north of Fruita, Utah, south to the Glen Canyon National Recreation Area. Three sites have been identified for the development of visitor facilities; they are, from north to south, (1) the Hartnet area in T. 27 S., R. 5,6,7 E., (2) the Fremont River area in sections 14 and 15, T. 29 S., R. 7 E., and (3) the Hall Creek area in T. 34 S., R. 8 E.

REGIONAL SETTING

The primary scenic values leading to the establishment of Capitol Reef National Park are the erosional landforms that occur along the

Waterpocket fold. The Waterpocket fold is a major east dipping monocline with over 7,000 feet of structural relief in parts of the park. Rocks from Permian to Cretaceous in age are exposed along the axis of the fold. Numerous ephemeral streams have eroded canyons across the fold, and the permanent Fremont river crosses the fold east of Fruita, Utah.

Stratigraphy

The sedimentary section exposed in Capitol Reef National Park includes about 7,000 feet of Triassic, Jurassic, and Cretaceous rocks. Most of these are fine-grained clastics including shales, claystones, mudstones, and redbed sequences. From the perspective of ground water geology, these rock types are unfavorable because their permeabilities are small and they contain minerals which are readily dissolved by the ground waters that circulate through them.

Two good aquifers occur under large parts of the park: the Triassic-Jurassic Navajo Sandstone, and the Jurassic Entrada Sandstone. The thicknesses of the Navajo and Entrada Sandstones in the three areas treated here range respectively from about 800-1,100 feet and 600-800 feet. Detailed stratigraphic descriptions and geologic maps dealing with the rocks in the park are found in Smith and others (1963) and Davidson (1967).

Smith and others (1963, p. 24) describe the Navajo Sandstone as "composed of loosely cemented chiefly fine-grained well-sorted well-rounded quartz sand grains. ...crossbedding on a grand scale is characteristic of the Navajo, and single lenses or sets of cross-strata are as much as 100 feet thick." Intersecting joints with regular spacings ranging from tens to hundreds of feet apart dominate the erosional

patterns on outcrops of the Navajo Sandstone along the Waterpocket fold. These joints are particularly important in ground water considerations because the fractures render the unit very permeable. Because jointing in the Navajo Sandstone is intensified along the fold, it is assured that permeabilities along the fold are substantially improved over the relatively undeformed parts of the Navajo aquifer east of the park. Hannah and Walter (1976) document a pump test conducted on an Intermountain Power Project industrial well that was drilled into the top 550 feet of the Navajo Sandstone east of Cainville, Utah, approximately 10 miles east of the Waterpocket fold. This well was pump tested at a continuous rate of 2,800 gallons/minute for 35 days during 1975. An aquifer transmissivity of 1.3×10^5 gallons/day-foot and storage coefficient of 10^{-3} were computed for the Navajo aquifer from the test. This test amply documents the potential of the Navajo Sandstone to yield water to wells drilled into it.

The Entrada Sandstone is described by Smith and others (1963, p. 27) as consisting "chiefly of even-bedded earthy fine-grained and very fine-grained sandstone with subordinate interbedded siltstone and claystone. Grains are mostly quartz and are subangular to subrounded. Sorting of the sand grains is moderately good to good, but many beds of fine-grained sandstone also contain coarse to very coarse grains. ...nearly all the beds are calcareous." The unit is less resistant to erosion than the Navajo Sandstone and forms a slope. Beds range from a fraction of an inch in thickness to over 5 feet. Joints are present but are not as obvious as those found in the Navajo Sandstone. As a potential aquifer, the Entrada Sandstone could possess sufficient permeability to yield

water to wells; however the composition of the unit will probably result in poorer water quality than should be expected from the Navajo Sandstone at the same location. The Utah Division of Water Resources (1975, p. 8) states that wells have been drilled into the Entrada Sandstone in the Hanksville area and have produced artesian flows of good quality from depths between 300 and 400 feet. Discharges range from 10 to 45 gallons/minute.

Alluvium, mostly comprised of fine-grained clastics and clay, occurs in the lowlands within the park. Stream gravels occur along the major washes in the area and along the Fremont river. Because these deposits are generally shallow, and well drained, they are not considered further in this report as a reliable source for water in the park.

Structure

The Waterpocket fold dominates the structural setting of the Capitol Reef area. The fold has over 7,000 feet of structural relief in the Hall Creek area. Small laterally and vertically discontinuous normal and reverse faults locally displace parts of the fold in the park. Because these faults are not extensive in the three areas under consideration, they do not significantly alter ground water circulation in the rocks. The jointing in the section, particularly in the Navajo Sandstone, becomes more intense in the immediate proximity of the fold. Because the joints enhance the permeabilities of the rocks, the transmissives of the Navajo and Entrada Sandstones in the region should be maximized within the park.

The Waterpocket fold has resulted in the uplift of the Navajo Sandstone on the west to elevations in excess of 8,000 feet where the unit

is fully exposed. The outcrops largely follow the anticlinal axis of the monocline and occupy the highland parts of the park. To the east, the unit becomes deeply buried under younger rocks. For example, at Hall Creek the base of the Navajo lies a few hundred feet above sea level, and at the Hartnet the base is about 3,000 feet above sea level.

Ground Water Circulation and Recharge

The direction of ground water flow in the Navajo Sandstone east of the Waterpocket fold has been determined by Hannah and Walter (1976) from available potentiometric data. Their Figure 12 illustrates that the flow is eastward away from the Navajo outcrop area along the Waterpocket fold in the Fremont River and Hartnet areas. In the Hall Creek area, the flow parallels the fold and the water moves generally southward. These data substantiate that the Waterpocket fold is a major recharge area for water entering the Navajo Sandstone.

Hannah and Walter (1976, p. 62-65) summarize recharge estimates made for the Navajo Sandstone along the entire Waterpocket fold. They show that approximately 29,900 acre-feet/year of precipitation falls on Navajo outcrops, and between 1,500 and 6,000 acre-feet/year of this water enters the unit as recharge.

During November, 1974, and June, 1975, the recharge directly from the Fremont river to the Navajo Sandstone exposed in the bed of the stream was estimated by stream gaging to be between 3 and 5 $feet^3/second$ (Hannah and Walter, 1976, p. 68-69). Such stream losses produce an average annual recharge of about 2,900 acre-feet/year from this source alone.

Circulation of water in the overlying Entrada Sandstone generally follows the same pattern as that in the Navajo Sandstone based on the similar structural configurations of the two units. However recharge rates to the Entrada can be expected to be substantially smaller than those to the Navajo Sandstone because the outcrops of the Entrada receive less rainfall and the unit has a smaller permeability.

Water Quality

Only one water quality analysis is available from the Navajo aquifer in Capitol Reef National Park, and that was obtained from the 460-foot-deep U.S. Geological Survey observation well shown on Figure 2. Total dissolved solids in this sample were 440 milligrams/liter (U.S.G.S., 1977). The next closest well that has been sampled for quality is the Intermountain Power Project OW-1A observation well completed in the Navajo Sandstone about 5 miles east of the Waterpocket fold in section 27, T. 28 S., R. 7 E. (Hannah and Walter, 1976, Table 5-4). The total dissolved solids in this sample were 690 milligrams/liter. The well lies about 6 to 10 miles downgradient from the recharge area along the Waterpocket fold.

A second useful set of analyses involves the water quality in the Fremont river near Fruita, Utah, reported by Marine (1962, Table 2). Samples taken in 1951 and 1958 had total dissolved solids respectively of 526 and 465 milligrams/liter. The significance of these samples is that the water from the Fremont river recharges directly to the Navajo aquifer east of Fruita.

Water infiltrating from direct precipitation on the Navajo outcrops along the Waterpocket fold will have substantially lower total dissolved solids than that in the Fremont river. In the immediate vicinity of the Navajo outcrops, the Fremont river water can therefore be expected to

provide the worst background waters entering the aquifer. Once in the aquifer, the water quality will decline with distance from the outcrop areas. The prospects are excellent, therefore, that the poorest quality water in the Navajo aquifer in the park will contain about 500 milligrams/liter of dissolved solids. In the Hartnet area, the water quality may be much better due to the proximity of large areas of exposed Navajo Sandstone that are recharged from direct precipitation on the outcrops.

No data exist on the water quality in the Entrada Sandstone inside the park. I speculate that it contains significantly more dissolved solids than that in the Navajo Sandstone because the matrix of the rock contains more readily dissolved impurities than found in the Navajo and because recharge rates to the unit are smaller.

DEVELOPABLE SUPPLIES

In each of the three areas considered, the primary drilling target is the Navajo Sandstone. At each site, the upper 500 feet of the Navajo Sandstone should be capable of producing at least 100 gallons/minute, and the probability is excellent that substantially greater yields can be expected from individual wells. In order to penetrate the Navajo Sandstone, it will be necessary to drill through the Entrada Sandstone at the Hartnet area. Once the Entrada aquifer is reached, its water yielding capability and the water quality contained within it should be tested. It is possible, but unlikely, that the yield and quality of water from the Entrada Sandstone could satisfy park needs in the Hartnet area.

Hartnet Area

The Hartnet area (see Figure 1 inside back cover) lies to the east of the Waterpocket fold and occupies the axis of the gently dipping Saleratus Creek syncline. The surface of the Hartnet is comprised of the Salt Wash Member of the Morrison Formation which, using the thickness data in Smith and others (1963), lies 1,800 feet above the top of the Navajo Sandstone. Figure 1 shows the elevation of the top of the Navajo Sandstone and the base of the Entrada Sandstone. There is a slight structural closure along the southeastward plunging axis of the Saleratus Creek syncline near the center of the area.

Ground water in the Navajo aquifer occurs under artesian conditions and circulates generally eastward in the area. The slope of the potentiometric surface is eastward from an elevation of about 5,700 feet on the west edge of the area to about 5,150 feet on the east (Hannah and Walter, 1976). The recharge area for this part of the Navajo aquifer lies to the west where the Navajo Sandstone crops out along the Waterpocket fold.

Ground water in the Entrada Sandstone probably occurs under semi-artesian conditions and circulation is locally parallel to the plunge of the Saleratus Creek syncline. Large volumes of the Entrada Sandstone along the flanks of the Hartnet are unsaturated because the unit crops out and is well drained in these areas. The thickest saturated zone within the Entrada aquifer in the Hartnet area occurs within the 4,200 foot Entrada contour shown on Figure 1 in the center of the area.

The water quality in both the Navajo and Entrada formations in the Hartnet area is unknown. However, because the recharge area for the Navajo aquifer is immediately to the west and most of the recharge comes

from infiltration of rainwater directly on the outcrops, the expected water quality in the aquifer should be very good. Possibly it contains as little as 350 milligrams/liter total dissolved solids. Of the three areas treated in this report, I anticipate that the Navajo Sandstone will yield the best quality water from under the Hartnet area.

The possibility of developing a dependable supply of good quality water from the Entrada Sandstone in the Hartnet area is fair at best. If a high priority is given to a test of the Entrada aquifer, the test hole should be drilled within the area outlined by the 4,200 foot Entrada contour on Figure 1 in the center of the area. This location will maximize the saturated thickness within the Entrada Sandstone. The approximate depth of the well can be computed by subtracting the elevation of the base of the Entrada Sandstone as shown on Figure 1 from the surface elevation of the site. Typical total depths will be about 1,100 feet.

A Navajo test well can be located any place east of R. 5 E. and the well should penetrate at least the upper 400 to 500 feet of the Navajo Sandstone. Total depths of the well can be computed by subtracting the elevation of the top of the Navajo Sandstone as shown on Figure 1 from the elevation of the site, and then adding 500 feet. Typical total depths on the Hartnet will be about 2,300 feet.

Fremont River Area

The Fremont River area is located on the Waterpocket fold at the intersection of the Fremont river canyon and a valley eroded along the outcrops of the Entrada Sandstone. The prospects for developing ground water from either the Navajo or Entrada sandstones in the area are excellent because the Fremont river recharges these units here. Figure 2

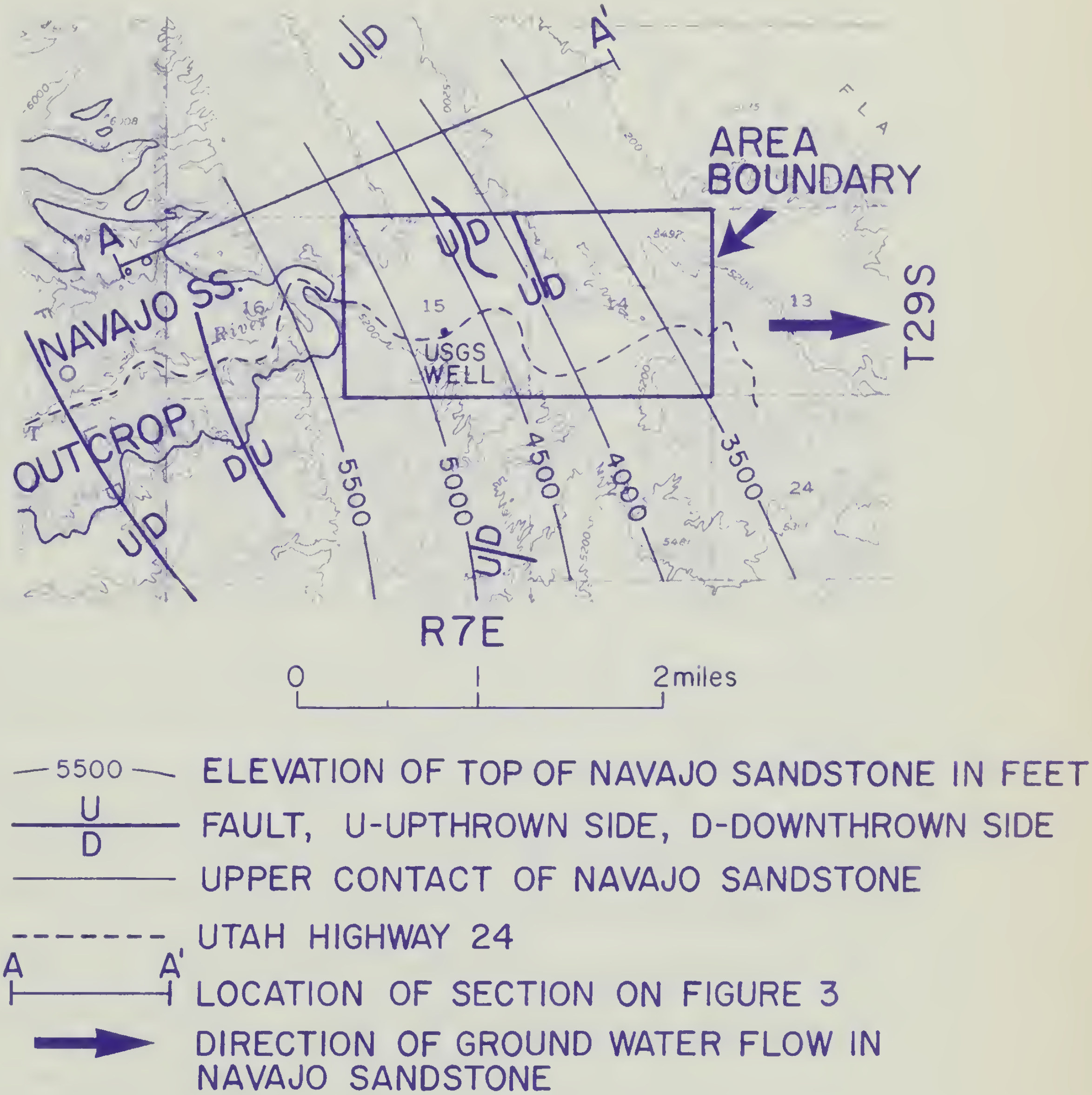

Figure 2. Elevation of the top of the Navajo Sandstone, ground water flow direction, and faults, Fremont River area, Capitol Reef National Park, Utah.

shows the elevation of the top of the Navajo Sandstone and Figure 3 shows a cross section just north of the area.

Ground water will occur under artesian conditions in the Navajo Sandstone in this area. Ground water in the Entrada Sandstone will be partially confined. Water qualities in either unit should closely resemble those in the Fremont river and will have total dissolved solids on the order of 450 to 550 milligrams/liter.

Test wells could be drilled into either unit, although I would recommend that the Navajo Sandstone be given highest priority due to its greater permeability. A Navajo test should penetrate at least the upper 400 to 500 feet of the Navajo Sandstone. In order to minimize the total depth of the well, the well should be located east of the axis of Deep Creek (see Figure 3). The total depth of the well can be computed by subtracting the elevation of the top of the Navajo Sandstone shown on Figure 2 from the elevation of the site, and then adding 500 feet. Typical total depths will be 700 to 800 feet.

An Entrada test well should be located east of Deep Creek and penetrate to the base of the unit. The faulting indicated on Figures 2 and 3 in the Entrada outcrops probably enhances the permeabilities of the unit a small amount locally. An Entrada test should be considered only if a Navajo test is infeasible.

Hall Creek Area

There is about 7,000 feet of structural relief across the Waterpocket fold in the Hall Creek area (Figure 4). The Navajo Sandstone crops out in the highlands to the west and dips steeply eastward under the Entrada sandstone which crops out along the west side of Hall creek.

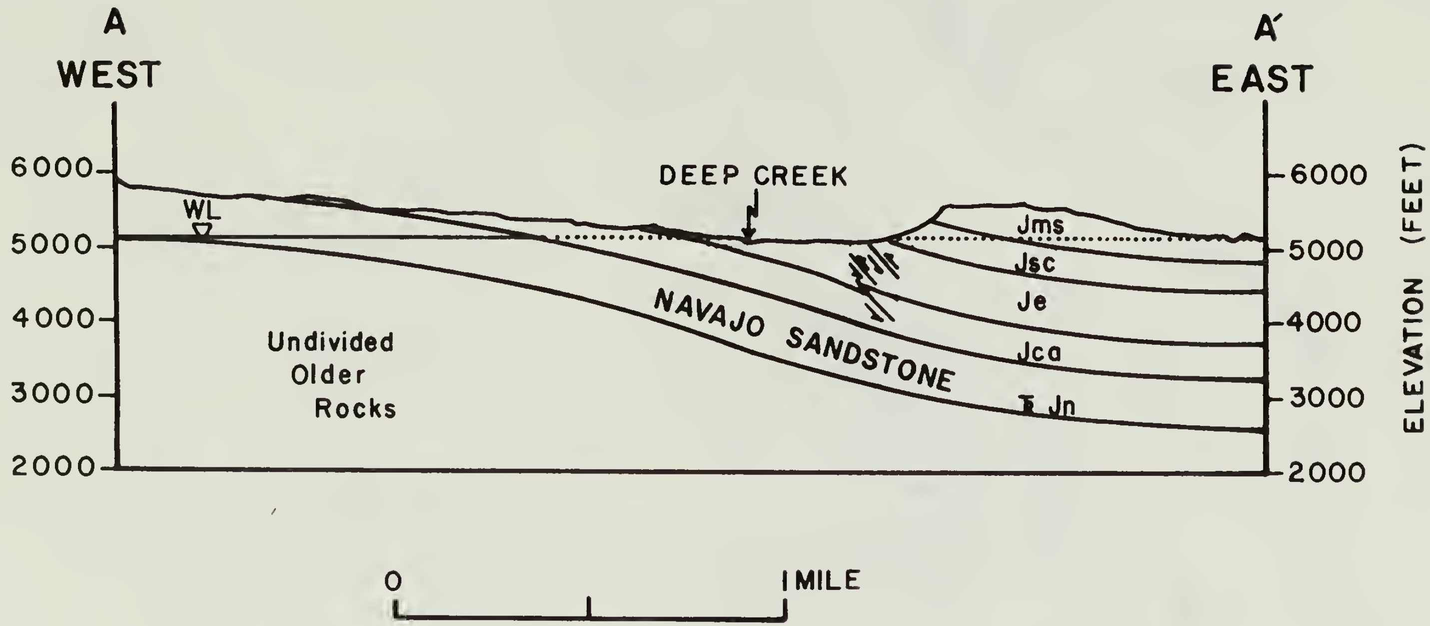

Figure 3. Structural cross section just north of the Fremont River area, Capitol Reef National Park, Utah. Jms - Salt Wash Sandstone Member, Morrison Formation; Jsc - Summerville and Curtis Formations; Je - Entrada Sandstone; Jca - Carmel Formation; ŦR Jn - Navajo Sandstone; WL - water level in the Navajo Sandstone; dots indicate projection of potentiometric surface; from Hannah and Walter (1976). Section location on Figure 2.

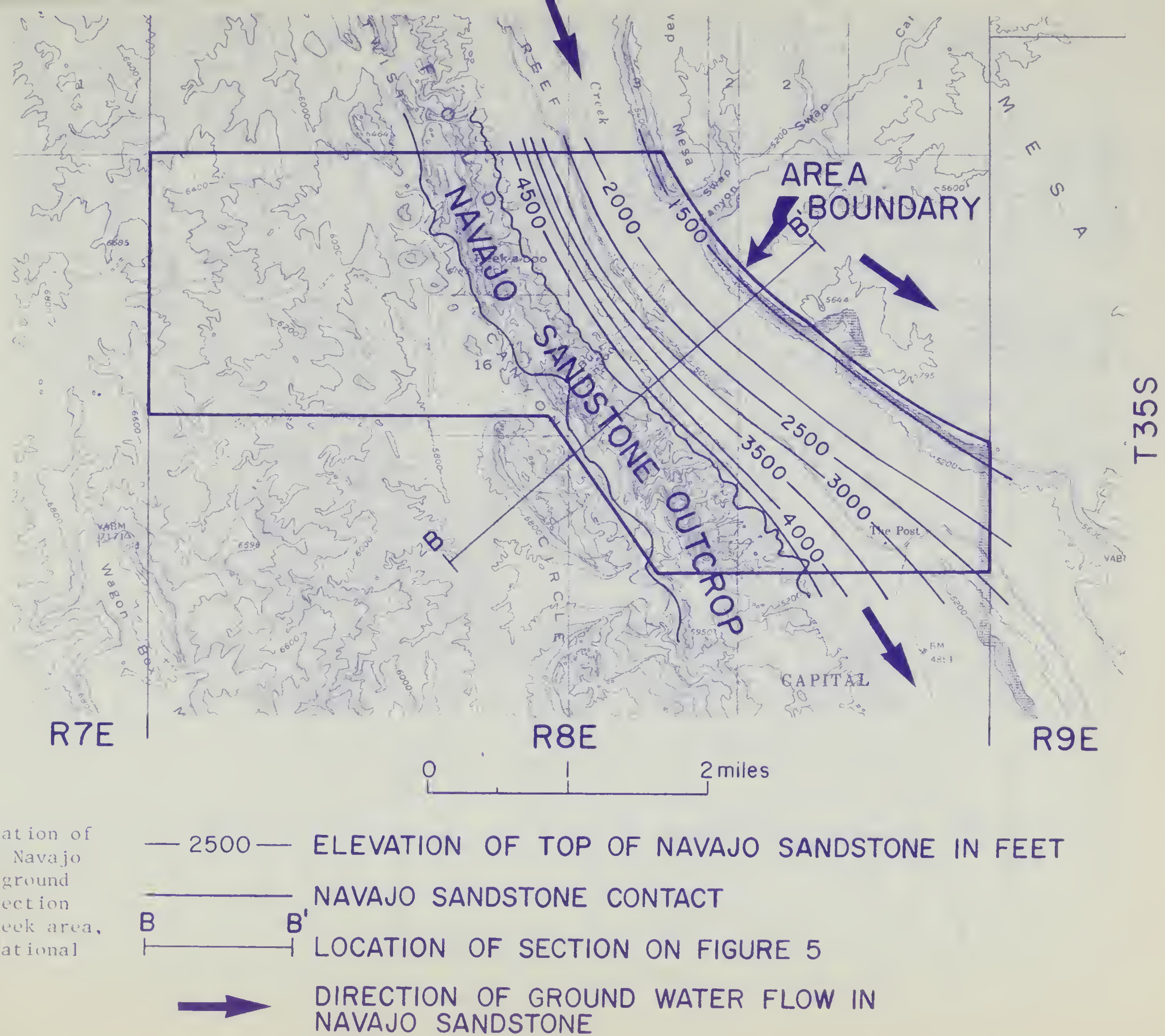

Figure 4. Elevation of the top of the Navajo Sandstone and ground water flow direction in the Hall Creek area, Capitol Reef National Park, Utah.

Figure 4 shows the elevation of the top of the Navajo Sandstone and Figure 5 is a cross section through the area.

Groundwater is under artesian conditions in both the Navajo and Entrada sandstones in the area east of these outcrops. Groundwater flow in the Navajo aquifer is southeastward parallel to the Waterpocket fold (Hannah and Walter, 1976), and receives some recharge from the outcrops in the western part of the area.

The water quality from the Navajo aquifer is probably going to be intermediate between that found in the Hartnet and Fremont River areas because it should contain a mixture of Fremont river recharge water and the water recharging directly through the Navajo outcrops along the Waterpocket fold. Entrada water will undoubtedly contain more total dissolved solids than the Navajo waters, therefore making this aquifer somewhat less attractive for development at this site.

The best location for a Navajo test well is along a line that is 1/3 of a mile west of Hall Creek. Such a position would minimize the depth of the well yet intersect a part of the Navajo aquifer that is fully saturated (see Figure 5). Approximately 400 to 500 feet of the Navajo Sandstone should be penetrated. Typical total depths of the test well will be on the order of 1,200 feet. Placing the well on the east side of Hall Creek would result in excessive drilling depths as a result of the steep dips in the area. The total depth of a Navajo test well can be computed from Figure 4 by subtracting the elevation of the top of the Navajo Sandstone from the site elevation, and adding 500 feet.

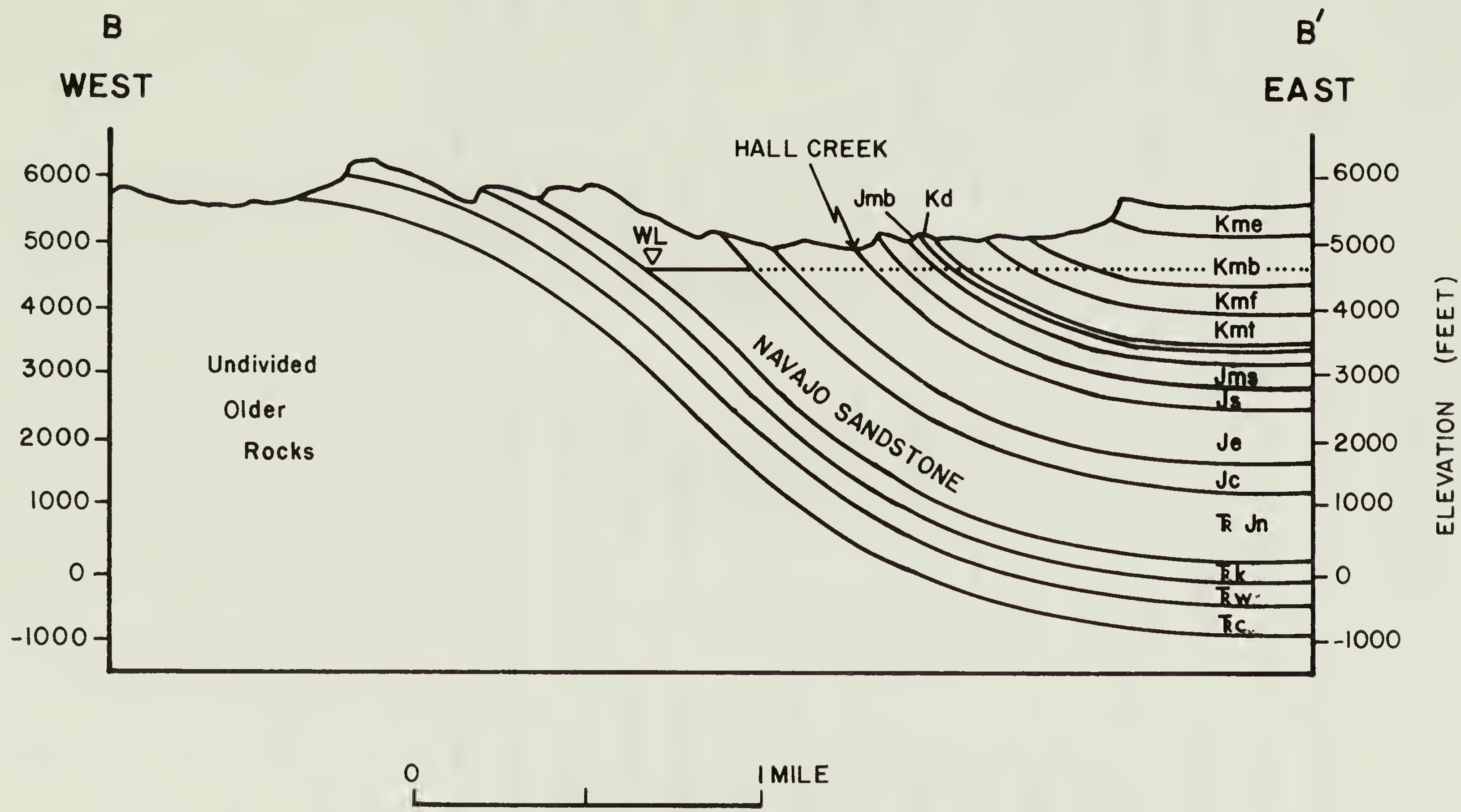

Figure 5. Structural cross section in the Hall Creek area, Capitol Reef National Park, Utah. Kme - Emery Sandstone Member, Mancos Shale; Kmb - Blue Gate Shale Member, Mancos Shale; Kmf - Ferron Sandstone Member, Mancos Shale; Kmt - Tununk Shale Member, Mancos Shale; Kd - Dakota Sandstone; Jmb - Brushy Basin Shale Member, Morrison Formation; Jms - Salt Wash Sandstone Member, Morrison Formation; Js - Summerville Formation; Je - Entrada Sandstone; Jc - Carmel Formation; Ʀ Jn - Navajo Sandstone; Ʀ k - Kayenta Formation; Ʀ w - Wingate Sandstone; Ʀ c - Chinle Formation; WL - water level in the Navajo Sandstone; dots indicate projection of potentiometric surface; from Hannah and Walter (1976). Section location on Figure 4.

RECOMMENDATIONS

In all three sites considered in this report, the Navajo Sandstone is the most attractive target aquifer because the unit has good permeability and contains water with the best quality in the sedimentary section. The problem with Navajo wells is that they will be between 700 and 2,300 feet deep. The best water quality in the Navajo aquifer can be expected in the Hartnet area, the worst at the Fremont River area.

I recommend that test drilling proceed in the following order (1) Navajo-Entrada test in the Hartnet area, (2) Navajo test in the Fremont River area, and (3) Navajo test in the Hall Creek area. In the Hartnet area, the test well will penetrate the Entrada Sandstone and if water is found, the aquifer should be tested for quality and yield. Should the Entrada supply prove attractive, drilling can cease, and the supply can be developed. If the supply has poor quality or yields are low, drilling can proceed to the Navajo Sandstone. The feasibility of developing supplies from the Fremont River and Hall Creek areas should be contingent upon the water quality obtained in the Hartnet area.

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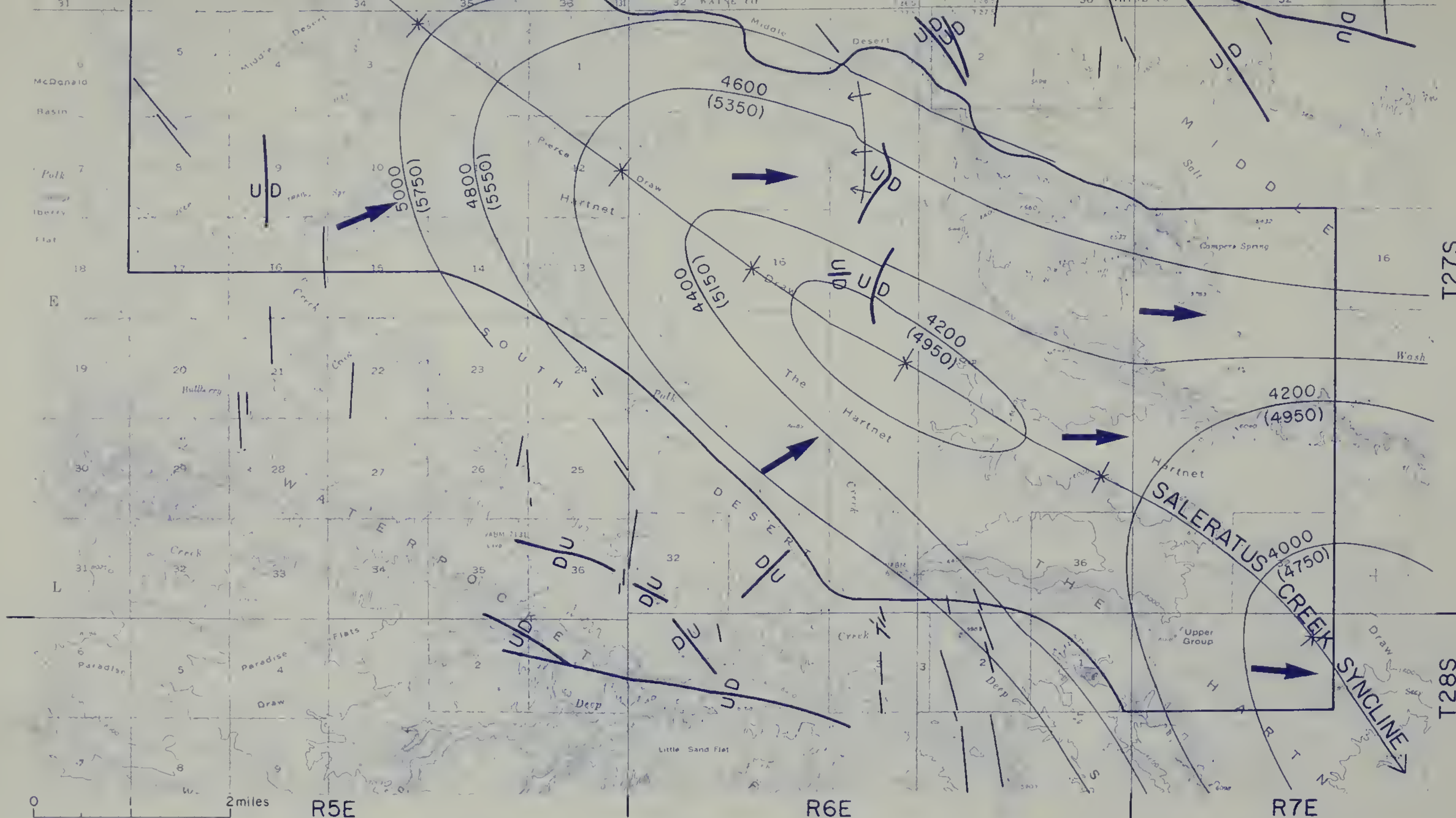

5000 / (5750) — LINE OF EQUAL ELEVATION IN FEET, 5000-TOP OF NAVAJO SANDSTONE, (5750)-BASE OF ENTRADA SANDSTONE

U / D — FAULT, U-UPTHROWN, D-DOWNTHROWN

BASALT DIKE

AXIS OF SYNCLINE, ARROW SHOWS DIRECTION OF PLUNGE

MONOCLINE, ARROW SHOWS DIRECTION OF DIP

DIRECTION OF GROUND WATER FLOW IN NAVAJO SANDSTONE

FIGURE I. ELEVATION OF THE TOP OF THE NAVAJO SANDSTONE AND BASE OF THE ENTRADA SANDSTONE, GROUND WATER FLOW DIRECTIONS, AND TECTONIC STRUCTURES IN THE HARTNET AREA, CAPITOL REEF NATIONAL PARK, UTAH.